

Phasing of Debuncher Stochastic Cooling Transverse systems.

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With the higher frequency of the cooling systems in the Debuncher, a modified method of making transfer functions has been developed for transverse systems. (Measuring of the momentum systems is unchanged.) Phasing can be performed with either forward protons or antiprotons. At least two of the momentum cooling systems must be operating properly. A nominal 3-Hertz beam width is effective for making transverse transfer functions. If the beam width exceeds 10 Hz, the quality of the measurement will be reduced. Beam width is defined as the 3 dB bandwidth of the longitudinal Schottky divided by 127 (the harmonic of the Schottky pickup in the Debuncher.) The momentum cooling is so effective (even with the gain turned down) that the momentum width normalized to f_0 becomes less than one Hertz on the Schottky pickup. A beam this narrow requires very precise measurement of tune and revolution frequency. It is difficult to get repeatable results.

To produce a wider beam width, two momentum systems can be anti-phased to spread out the beam. First, it is important to verify that both momentum cooling systems cool the beam to the same revolution frequency. The BAW notch filters should be adjusted to get the beam to the same revolution frequency independently. Calculate a new trunk delay time that will provide a 180-degree phase shift at midband of one of the momentum cooling systems. For example, in Band 2, midband is approximately 5.4 GHz. This corresponds to a wavelength time of 186 ps. Divide this by two to get a delay change of 93 ps for a 180-degree phase shift. On this same system, reduce the gain to minimum with the variable gain trunk amplifier. What this will do is effectively have one momentum system fighting the other, hence spreading the beam width. By controlling the gain ratio of the cooling and heating momentum systems, the beam width can be controlled effectively.

Speed in making the measurements is critical with antiprotons because of the re-triggering of DRF1 at 2 minute intervals. (RF bunch rotation is critical with antiprotons; hence, DRF1 must be functional. This is not an issue with protons.) In the 4-8 GHz band, the harmonics in the Debuncher are 6,700 to 13,400 times the revolution frequency. Every Hertz change in revolution frequency is multiplied by this harmonic number and becomes a frequency measurement error, which is an appreciable percent of the momentum width of the beam. Knowing the revolution frequency and beam width to 0.5 Hz is important.

Settings on the network analyzer application program are adjusted for maximum measurement speed. Data is not analyzed until a complete set of measurements is taken. Start and stop frequencies should be chosen to be just slightly wider than the band being measured. (example in Figure 1) Select betatron both for the measurement type. Select

101 for the number of points, sweep time of 7 seconds, IF bandwidth 30 Hz, averages = 1.

With forward protons, there are also signs that the front-end amplifiers saturate with beam currents above several hundred microamps. The cooling systems were designed to be very sensitive, (that's why the front end is at liquid helium temperature) so a hundred microamps will go a long way. (Signal to noise ratio of 30 dB @ 100 microamps protons was observed.) For antiprotons, beam lines and target station should be tuned up for maximum Pbar production.

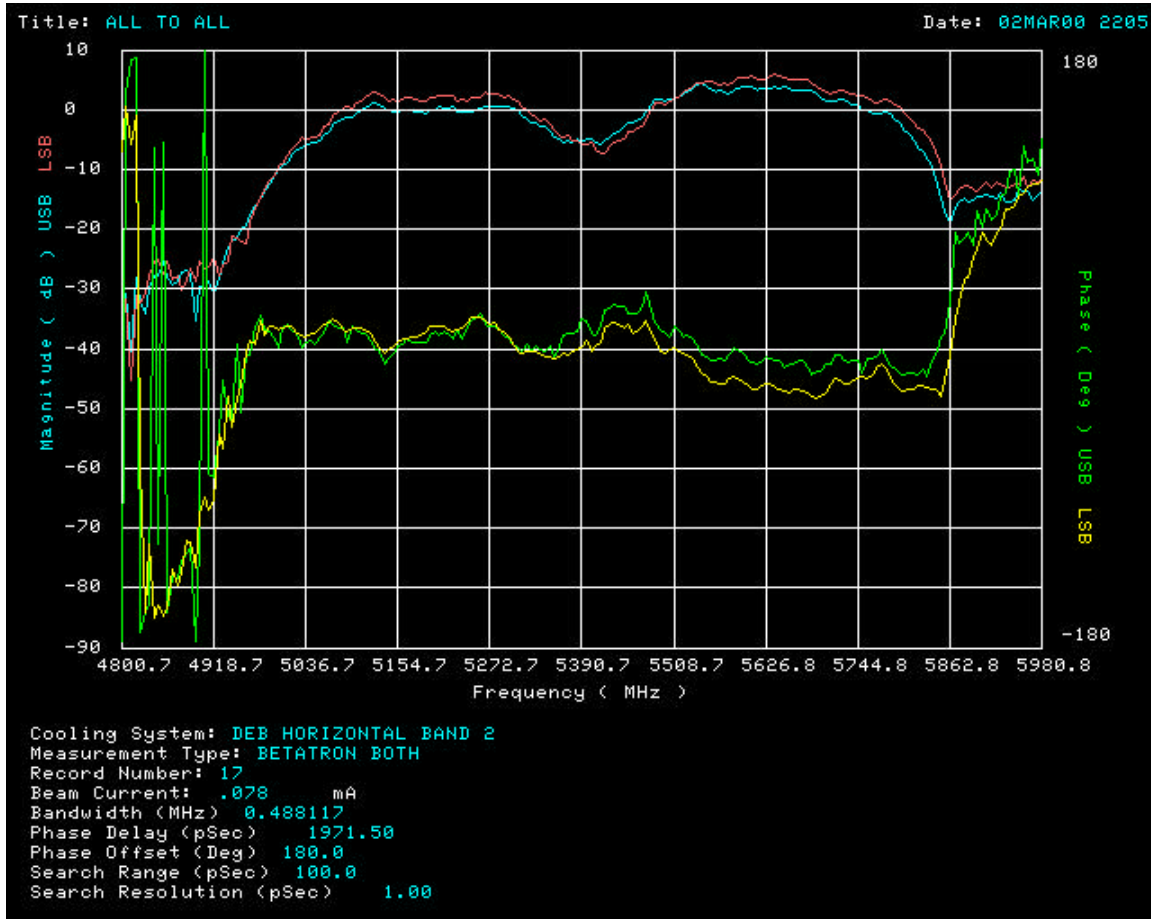


Figure 1. Horizontal Band 2 transfer function with both USB and LSB. Beam current is 78 microamps forward protons.

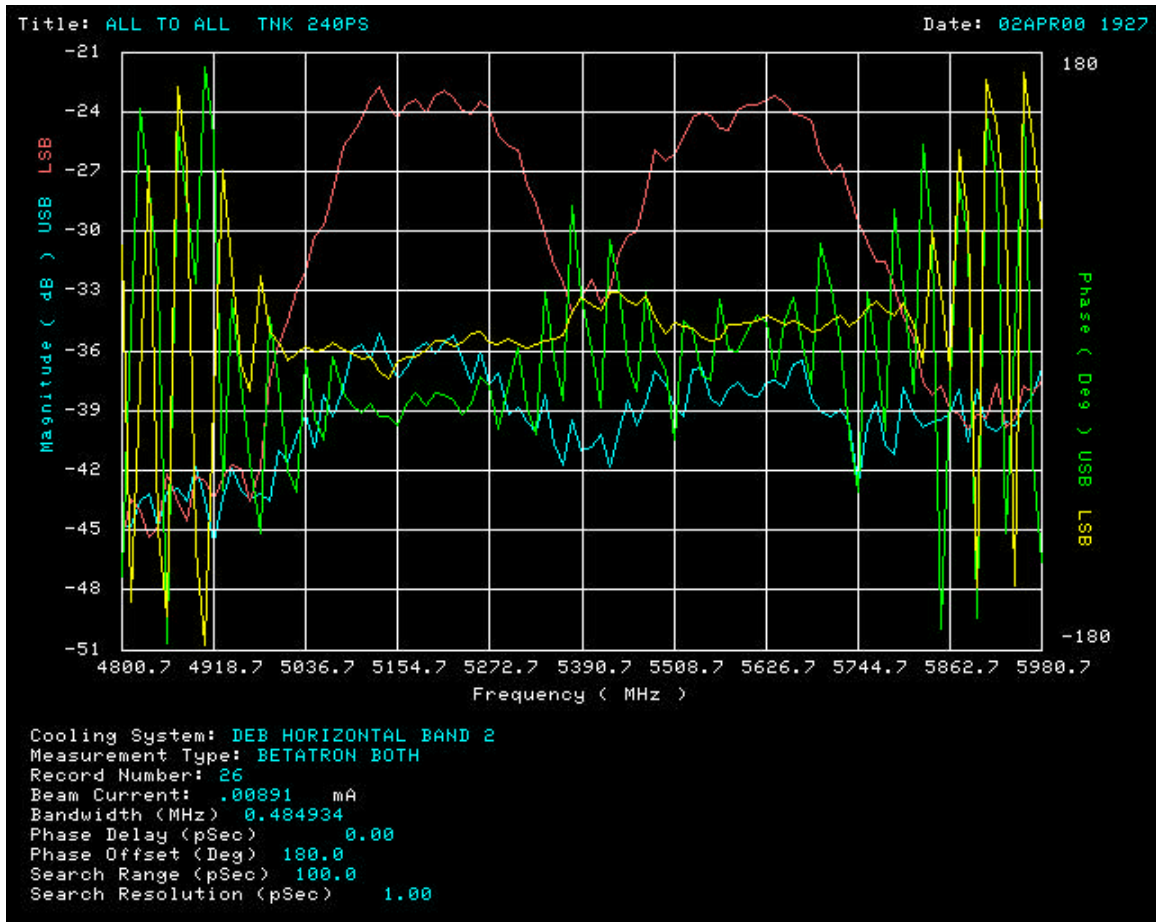


Figure 2. Horizontal Band 2 with Antiprotons. Note signal to noise ratio reduced and poor amplitude of one sideband.